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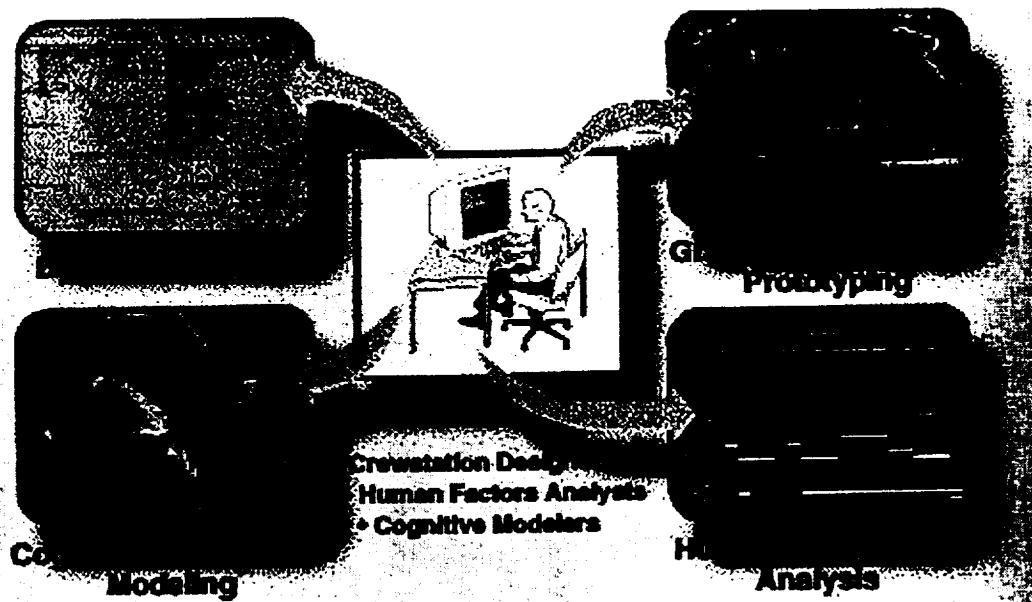
Man-machine Integration Design and Analysis System



MIDAS, Man-machine Integration Design and Analysis System, is a unique combination of software tools aimed at reducing design cycle time, supporting quantitative predictions of human-system effectiveness and improving the design of crew stations and their associated operating procedures. This project is supported jointly by the U.S. Army and NASA.

To the left of the screen you will see a navigation bar. By selecting one of the categories you will be taken to the relevant area.

Last Revision: August 1997

Web Curator: Allen Goodman

Cognitive & Perceptual Modeling

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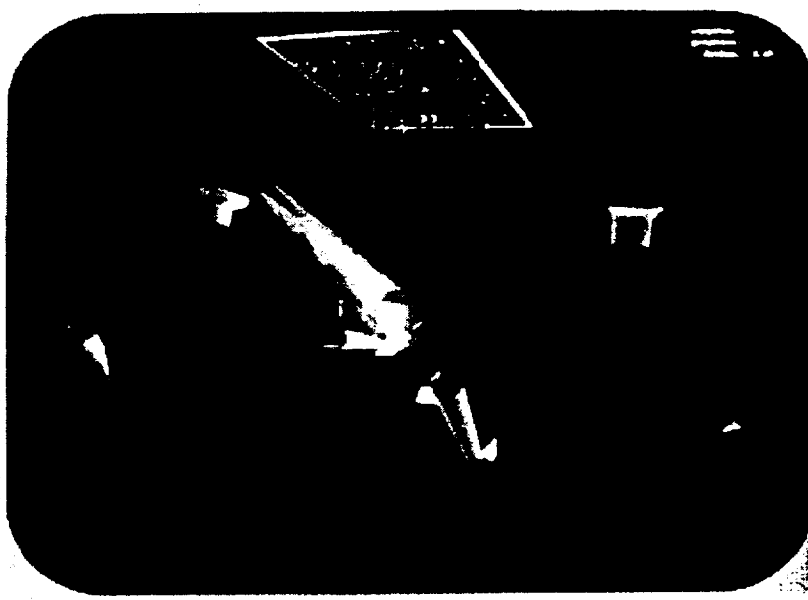

To produce a stream of human-system behavior during a mission simulation, MIDAS includes models of the operator's **visual perception and attention, memory, decision making, and scheduling**. The aggregation of these human performance elements is termed the Symbolic Operator Model (SOM). From the interaction between the SOM and the constructed World Model (which includes vehicle, cockpit equipment, and gaming area), the analyst is provided quantitative data about activity execution, memory accesses, and workload. For further information see Embedded Models page of the Design section of this website.

Dynamic Simulation

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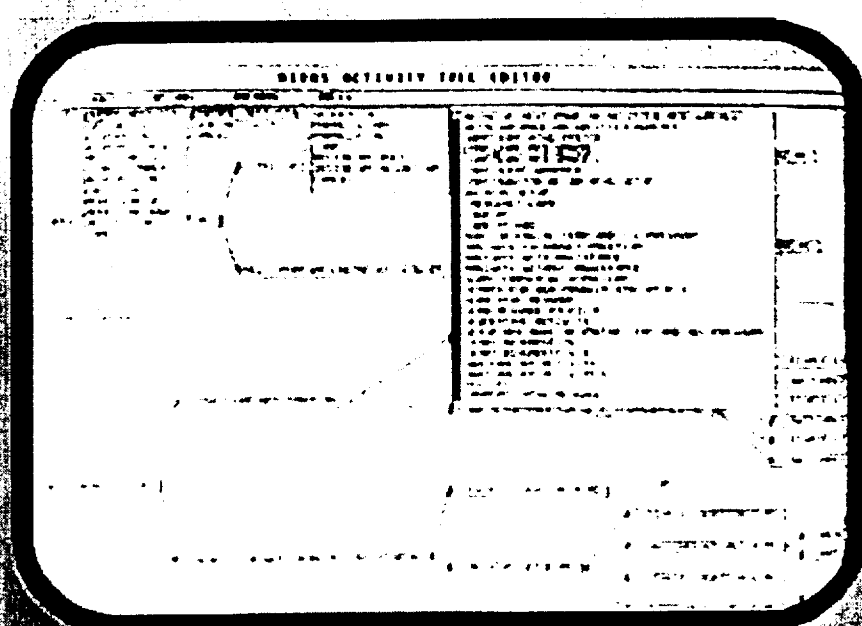

MIDAS provides facilities whereby specifications for the human operator, cockpit equipment, and mission procedures are integrated into a viewable time-based dynamic simulation. Execution results include activity traces, task load timelines, information requirements and mission performance measures. MIDAS simulations are intended to supplement, not replace, full mission, human-in-the-loop simulators. Therefore, the simulation focus has been 10 to 25 minutes scenario segments, in which the human-system interactiion for that segment could be modeled in detail. For further information see the Design page in this website.

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Applications

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Research Team

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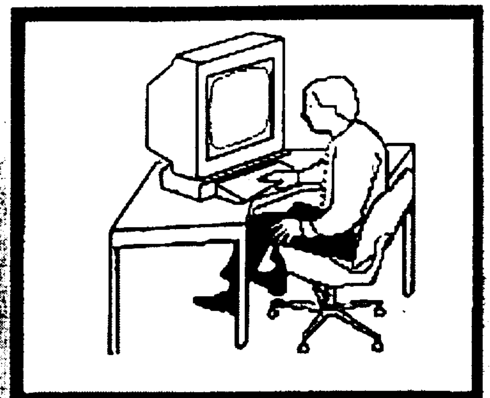

- Crewstation Designers
- Human Factors Analysts
- Cognitive Modelers

MIDAS is a workstation-based simulation system for crew station human engineering design and analysis. As such, the system is intended to support crew station designers and human factors specialists in making evaluations of candidate crew procedures, controls, and displays early in the development cycle prior to more expensive and time consuming human subject experiments.

Additionally, through the modularity of its architecture, the MIDAS system provides a unique testbed for cognitive modelers to evaluate the performance consequences of different component models of human cognition and perception. For further information see the Design page in this website.

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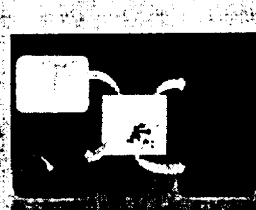
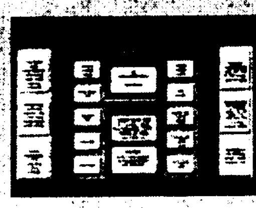
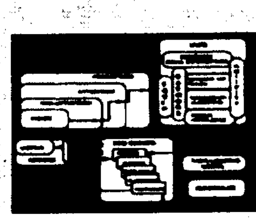
Select one of the categories below for a brief summary of MIDAS and its components.



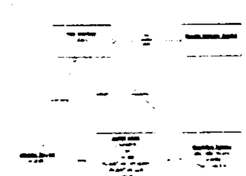
Overview



Architecture



Embedded Models



New MIDAS Design

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Overview

MIDAS is a unique workstation-based simulation system developed by the U.S. Army, NASA, and Sterling Software Inc. that contains models of human performance which can be used to evaluate candidate crew procedures, controls, and displays prior to more expensive and time consuming human subject experiments. Several aviation applications have demonstrated MIDAS' ability to highlight procedural or equipment constraints and produce human-system performance measures early in a platform's lifecycle.

The Man-machine Integration Design and Analysis System combines graphical equipment prototyping, a dynamic simulation, and human performance modeling with the aim to reduce design cycle time, support quantitative predictions of human-system effectiveness, and improve the design of crew stations and their associated operating procedures.

As an exploratory development program, the MIDAS software has progressed through seven development phases which culminated in capabilities demonstrations. Recent effort has included not only increasing the depth and range of human performance elements, but also applying the emerging system to specific platforms and operational problems. While MIDAS fundamentally remains a research program to advance human performance modeling, considerable emphasis has been placed on usability, software standards, and collaborations with users.

Design | Architecture | Embedded Models | New MIDAS Design

Design

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Description of the System

The existing system contains a set of integrated software modules, edito and analysis tools produced in C, C++, and Lisp, with an architecture based agent-actors theory.

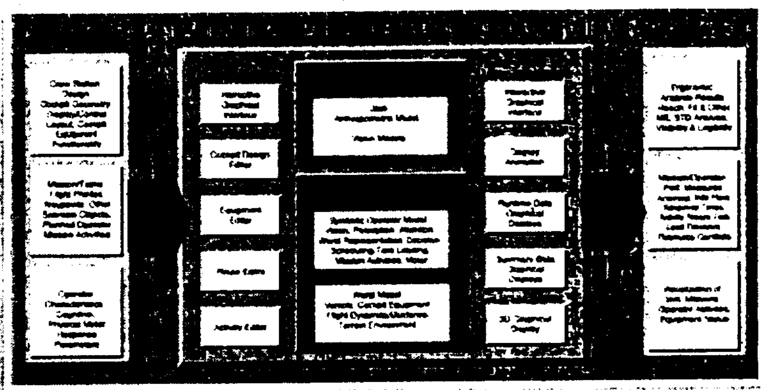

Figure 1: User View of MIDAS
(click on the figure to view a larger image)

Each major component, or agent, contains a common message passing interface, a body unique to that agent's purpose, and a common biographer structure which keeps track of important state data or events for analysis. This uniform representation was chosen to provide modularity. The total system contains 350,000 executable lines of code, with about half of the associated with a dynamic anthropometry model.

Once a user inputs or specifies operator, task, and equipment characte MIDAS operates in two major modes. The first, Interactive Mode, supports scenario-independent layout of the crew station for assessments of visib and legibility, (next page)

Design | Overview | Embedded Models | New MIDAS Design

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MIDAS
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New MIDAS Design

Although application directed work with the existing software comprises half of the progra funding, a major effort to rearchitect the MIDAS system is also underway. The goals driving this redesign include decreasing development time for new scenarios (from several months one or two weeks), increasing the efficiency of the running system (from around 50 times re time to near real- time), facilitating the process of replacing cognitive and perceptual model (from weeks to days), and expanding the functionality of the system as detailed below.

Presently, MIDAS is implemented in a combination of C/C++ and LISP, with the huma performance elements being largely LISP- based. As a result, supporting the interaction modules in different languages and trying to map design concepts uniformly across ver different programming paradigms (e.g., the notion of agent), has proved difficult. In additio while it began with a fairly rigorous design process, over the years MIDAS has acquired number of idiosyncratic and hard-wired features, simply due to time constraints and the of complex software evolution. The resulting system is difficult to learn, maintain, and mod There was also a desire to update the human operator model - in particular to account fo more widely accepted views on human information processing and its likely underlying architecture.

For these reasons, a research phase is underway with the goal of redesigning MIDAS object-oriented techniques and implementing the system entirely in C++. While human analysis will remain the key purpose of the system, the new design was not intended to directly to the existing version of MIDAS. Further, the described applications and other research in human modeling demanded expanded functionality for the system in severa areas. These included enhancements of the human operator model to encompass more complete notions of attention and working memory, as well as support for modeling multip human operators and their interactions. Further emphasis also needed to be placed on the human-computer interface of the system, as well as adding an explicit simulation analysis environment to enable a more complete examination of simulation results.

The approach taken in MIDAS' redesign is object-oriented rapid prototyping. Initial desig efforts produced a high-level system architecture with the following elements: a **domain model** supporting components necessary for running a simulation; a **graphics system** enable simulation visualization; an **interface** for end user specification of the target doma models; a **simulation system** for controlling the simulation and collecting data therefrom; and a **results analysis system** for examining simulation data after it has been collected

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Below is a review of completed MIDAS applications.

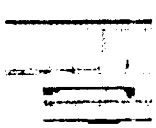
Air Warrior - An Integrated Protective Aviator Suit

Air MIDAS

Short Haul Civil Tiltrotor

Taxi MIDAS - A Preflight Checklist Study (747 - 400)

911 MIDAS - Emergency Dispatch Console Design Study



Westinghouse MIDAS - Nuclear Power Plant Study

Air Warrior

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Air Warrior (AW) is a program focused on the development of the 21st Century air crew life support system. This joint U.S. Army/ Navy program seeks to develop and operationally evaluate a survivability suit that will enhance air crew capabilities and performance. Air Warrior will also provide protection against battlefield hazards, such as crashes, chemical agents, and small arms fire.

The current protection suit is bulky, heavy, hot, has a limited field-of-view, and is incompatible with many avionics systems. To address these issues as well as provide increased mission capability and performance, AW will seek to integrate several technology areas such as protective clothing, laser protection, micro-climatic cooling, helmet mounted displays, The program will be carried out in two phases.

The near term program focuses on "quick-fixes". Those items, or integration of items, that can quickly be fielded and provide a degree of increased capability or performance. The second longer term phase focuses on the fully-integrated Air Warrior system that will serve U.S. air crews.

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Applications

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Brief Overview

With the goal of providing safer, more flexible, more fuel-efficient routing and increased capacity in enroute and terminal area operations, NASA and the FAA have undertaken a number of technology development efforts. These programs are exploiting advances in flight management systems, communication and automation in Air Traffic Control (ATC) aiding. The Advanced Air Transportation Technologies initiative (AATT) and the Termi Area Productivity (TAP) program have research elements explicitly focused the development of technologies for effective integration of flight deck automation, flight crew, ATC, and ATC-aiding systems. This integration s produce optimized routing, sequencing, and scheduling in the terminal are while relaxing constraints in enroute environments to accommodate user-preferred routing and schedules. These goals are to be met by the development of aiding and communications technologies and the redefinitio roles and procedures in the National Airspace System.

- Next Page -

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Air Midas (Page 2)

Rationale

In order to explore the procedural implications of these changes and to guid the technological developments needed to support these goals, a predictive model of human operator performance (flight crew and ATC) has been developed and applied in order to evaluate the impact of automation developments in flight management and air traffic control. The model is us to predict the performance of flight crews and ATC operators interacting automated systems in a dynamic airspace environment. The purpose of the modeling is to support evaluation and design of automated aids for flight management and airspace management and to predict required changes in domains.

Model

The model represents the information requirements, decision processes, communication processes and motor performance required by the flight cre and air traffic controllers to integrate flight management automation and ground-side automation in clearance aiding. The model of human performa predicts decision-making and clearance enactment strategies for individu agents and the collective system and includes stochastic variations in environment and operator interruption.

The complex human performance model allows variations in system desig be explored through predictive simulation. Procedures and performance criteria as well as situational variations can be controlled and tested. The model and its supporting data provide a generalizable tool that is being expanded to include air/ground compatibility and ATC crew interactions in traffic management.

Page One | Next Page

Design

Applications

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Home

Air Midas (Page 3)

Air MIDAS I

Experiment 1: Exploring an Optimum Time Range for Issuing a CTAS Descent Clearance.

The MIDAS simulation architecture and editing tools were used to develop model of the top of descent environment. The challenge was to explore an optimal range of time for the issuance of a CTAS descent clearance so that aircrew would be likely to accept the clearance and enact it using flight automation (as opposed to manually commanding the descent). CTAS calculations tend to favor a late issuance (close to the TOD); while the flight crew tends to favor clearance information as early as possible to aid them planning and configuring the aircraft. A full range of communication (Voice Datalink) and automation implementation modalities (Autoload, CDU (Control Display Unit), and MCP (Mode Control Processor)) were modeled.

Experiment 2: Evaluating Model Predictions vs. Human Performance

A follow-on experiment was performed to evaluate the predictive nature the model. The basic activity framework and conditions developed for the experiment were also used for the second. Human performance data (activity durations, interrupt durations and frequencies) were gathered from video computer analysis of a recent man in the loop study, referred to as the CTAS/DA experiment (Corker & Pisanich, in press). The model was used to predict the performance of (cont'd)

Page One | Page Two | Next Page

The **Short Haul Civil Tiltrotor** is a NASA program created to solve technical barriers to the production of a vertical takeoff and landing vehicle. This aircraft is designed to offload short commut traffic from the major commercial airports. Because this vehicle is in the concept phase MIDAS has potential to make a particularly valuable contribution.

SHCT research with MIDAS is being conducted under a Cooperative Research and Development Agreement (CRDA) with Boeing Helicopters.

Initial efforts consisted of importing existing geometric data into the MIDAS environment. Fro simple "flyby" demo was created where the MIDAS operator can view an approach and landing b SHCT into a concept vertiport. The landing can be viewed from outside the aircraft, or through th of the pilot. The subsequent efforts involved performing a legibility analysis of the cockpit multi-function displays under different seating configurations, and creating visibility analyses o cockpit.

The first complete simulation was a simple comparative study. We chose to compare two simpl procedures in two different tiltrotor cockpits. The procedure was setting a new heading. The two cockpits were the V-22 FSD, and a hybrid tiltrotor cockpit based on the Boeing 747-400. The co study is currently access limited.

- Back to Applications -

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Taxi MIDAS

In this demonstration we looked at a 747 commercial airline as the application domain.
This scenario was not geared towards solving a particular design problem. It was developed in support of a Cognitive Modeling Workshop held recently at NASA Ames Research Center, where the goal was to compare and contrast various approaches to modeling human performance. A pilot in a 747-400 on the ground completes the majo tasks to be performed before takeoff including a pre-start checklist, waiting for a clearance message from air traffic control, starting the engines, diagnosing engine problems, and taxiing out to the runway.

The goal of this demonstration was to highlight the range of cognitive modeling capabilities of the MIDAS approach. Nearly all the available MIDAS elements are employed in this scenario, giving an overall feel for how the system works as a whole. The pilot's behavior in this scenario was captured from an examination of commercial airline checklist manuals and from actual runs of pilots through NASA's highly realistic 747-400 Simulator Cab.

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gpisanich@mail.arc.nasa.gov

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The Design and Application of MIDAS: A Constructive Simulation fo[r] Human-System Analysis (1997)
Barry R. Smith: U.S. Army Aviation RDEC, Ames Reseach Center, CA
Sherman W. Tyler: Sterling Software Inc, Ames Reseach Center, CA
Download (632 k document)

A Cognitive System Model for Human/Automation Dynamics in Airspa[ce] Management (1997)
Kevin Corker: Ames Reseach Center, CA
Greg Pisanich: Sterling Software Inc, Ames Reseach Center, CA
Marilyn Bunzo: Sterling Software Inc, Ames Reseach Center, CA
Download (380 k document)

A Computational Model of Situational Awareness Instantiated in MIDAS ...
R. Jay Shively: U.S. Army Aviation RDEC, Ames Reseach Center, CA
Michael Brickner: PAMMAM HFE Ltd., Tel Aviv, Isreal
Jacob Silbiger, Synergy Integration Ltd., Tel Aviv, Isreal
Download (434 k document)

A Predictive model of Flight Crew Performance in Automated Air Traffic Co[n...] and Flight Management Operations (1995)
Greg Pisanich: Sterling Software Inc, Ames Reseach Center, CA
Kevin Corker: Ames Reseach Center, CA
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An Architecture and Model for Cognitive Engineering Simulation Analysis: Applications to Advanced Aviation Automation (1993)
Kevin Corker: Ames Reseach Center, CA
Barry R. Smith: U.S. Army Aviation RDEC, Ames Reseach Center, CA
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(http://www.arc.nasa.gov)

[illegible]

NASA Homepage
(http://www.nasa.gov)

[illegible]

Army Human Factors: Human Research and Engineering, Division of the Army Research Labs
(http://info.arl.army.mil/ARL-Directorates/HRED/hred.html)

[illegible]

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